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REPORT

OF THE

CANADIAN OBSERVATIONS

OF THE

TRANSIT OF VENUS.

6th DECEMBER, 1882.

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University of New Brunswick

REPORT

OF THE

CANADIAN OBSERVATIONS

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TRANSIT OF VENUS.

6th DECEMBER, 1882.

OBSERVATORY, TORONTO,
13TH MAY, 1883.

TO THE HON. A. W. MCLELAN,
Minister of Marine and Fisheries,
Ottawa.

SIR,

I have the honor to report in reference to the preparation for, and results of the observations in Canada of the Transit of Venus of 6th Dec., 1882.

Having, in the spring of last year, had the honor to be entrusted by the Government with the general arrangements, in Canada, for observing the transit, and with procuring the necessary instrumental equipment, I instructed Lieut. Gordon, R. N., to proceed to England, and purchase various instruments, and to take the opportunity of visiting Oxford, to ascertain the exact way in which the English observers were being trained, and if possible himself to obtain some instruction. I also requested him to endeavour to obtain a practice model for use in Canada, as the time was very short for having anything made. In carrying out these instructions he was fortunate enough to be successful in every particular; he also obtained from the Admiralty the loan of four Chronometers.

Early in September the model was erected at McGill University, Montreal, and Dr. Jack, President of the New Brunswick University, Professors Johnson and McLeod, of McGill University, and Mr. Chandler, practised with me in taking observations of the contacts on the model. It is unnecessary to enter into any details of this practice; I may, however, state that Professor McLeod who was the only one of the party who succeeded in obtaining observations of the actual transit, nearly always agreed with myself, within half a second, in the time he assigned to the contacts; except when the circumstances of observation were very unfavourable owing to tremor from passing vehicles, or when sudden changes in the illumination occurred, which sometimes happened when the mirror in connection with the model was used.

After leaving Montreal, I visited Quebec, Fredericton, and Kingston, and on my return to Toronto, ordered such small additional appliances as were necessary to complete the equipment of these observatories for the purpose of the transit, During my absence Lieut. Gordon had visited Woodstock, and ascertained what was necessary to be done at the observatory there.

In November the model was set up on the tower of the University Buildings, Toronto, and the following gentlemen attended for practice:—Professor Williamson, Queen's University, Kingston, Professor Bain, and Dr. Haanel, Victoria University, Cobourg, Professor Wolverton, Baptist College, Woodstock, Professor Hare, Ladies College, Whitby, Messrs. F. L Blake, D. L. S., W. Millar, and S. R. Roberts, Toronto, and Mr. Shearman, Brantford; as did also several members of the staff of the Meteorological office.

Arrangements had now been made for taking observations at the following places:

WINNIPEG.—Observer—Prof. McLeod; assistant, H. V. Payne. Instruments—A *four* inch *Achromatic Telescope Alt. Azimuth Mounting*, a *Transit Instrument, two Chronometers.*

WOODSTOCK.—Observer—Prof. Wolverton. Instrument—an *eight inch Refractor*, by Fitz of N. Y.; aperture reduced to six inches.

TORONTO.—Observer—Charles Carpmael, Director of the Observatory, assisted by members of the staff. Instruments—a *six* inch *Equatorial*, by T. Cook & Sons, York; a *three* inch *Transit* instrument, constructed by Troughton & Simms, London; *Sidereal Clock*, Arnold, London, Chas. Frodsham, No. 84; a *Mean Time* Clock, *Chronometers*, &c.

WHITBY.—Observer—Prof. Hare, Ladies' College; a *six* inch *Telescope* by Fitz of N. Y.

COBOURG.—Observer—Prof. Bain, Victoria University; a *four* and a *quarter* inch *Telescope* by Smith, Beck & Beck, London.

KINGSTON.—Observer—Prof. Williamson; assistant Prof. Dupuis. Instruments—A *six* and a *half* inch *Equatorial*, by Alvan Clark & Sons, of Cambridgeport, Mass. The *Beaufoy Transit* instrument; *Clock* by Prof. Dupuis, etc.

BELLEVILLE.—Observer—Mr. Shearman, *four* inch *Achromatic.*

OTTAWA.—Observer—F. L. Blake, D.L.S., assistant Mr. B. C. Webber. Instruments—A *four* inch Achromatic from McGill University; a *Transit* instrument lent by the Department of the Interior.

MONTREAL.—Observer—Prof. Johnson. Instruments—A *six* and a *quarter* inch Achromatic, and a *Transit* instrument, etc.

QUEBEC.—Observer—Lieut. Gordon, R. N., assistant W. A. Ashe, D. L. S. Instruments—An *eight* inch *Equatorial*, by Alvan Clark & Sons, aperture reduced to *six* inches.

HALIFAX.—Observer—Mr. A. Allison. Instruments—A *four* inch Achromatic, by Dollond.

CHARLOTTETOWN.—Observer—H. J. Cundall, C. E. Instrument—A *four* inch Achromatic.

FREDERICTON.—Observer—Dr. Jack. Instruments—A *seven* inch *Equatorial* reduced to *six* inches, a *Transit* instrument, etc.

As the instant at which certain phases appeared had to be noted, it was essential to the success of the observations that the various observers should have correct time, arrangements were accordingly made with the Great North Western, and Western

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Union Telegraph Companies, for an exchange of time signals, the observers at Halifax, Fredericton, and also at Montreal, exchanged time with Lieut. Gordon at Quebec; and Quebec, Montreal and all points in Ontario, with myself at Toronto, we had thus on the night before the Transit, a complete interchange between all stations, with the exception of Winnipeg; and it was further arranged that those stations, where observations were secured, should come on again for a second interchange on the night after the Transit, and accordingly, on the night of the 6th I again exchanged time with Cobourg, Belleville, Kingston and Ottawa, and also with Montreal. Prof. McLeod also made a determination of the longitude of his station at Winnipeg, by exchange of time signals with Prof. Hough of the "Dearborn" Observatory, Chicago, the Telegraph Companies both in the United States, and Canada placing the wires at our disposal for the exchange of these signals without making any charge.

On the day of the Transit, the stations at which contacts were secured were:—

WINNIPEG.—The two last contacts.

COBOURG.—Third contact, atmosphere, however, very unsteady.

BELLEVILLE.—Third contact, imperfect.

KINGSTON.—The second, third and fourth contacts.

OTTAWA.—The second, third and fourth contacts.

Before proceeding to the Reports of the various observers, it will be well to consider the errors of the Time-pieces employed. At all the stations, with the exception of Winnipeg, the times may be indirectly compared with the Toronto Clock, there having, as already stated, been an interchange both on the night preceding, and on the night following the Transit.

I have taken great pains to ascertain, as closely as I could, what were the errors of the Toronto Sidereal Clock on the two nights in question. In doing this I have met with unexpected difficulties, on examining the rates for the last eighteen years, during which no change has been made in the adjustment of the Clock, I find that the mean daily rates for the various months were as shewn in the following table:—

TABLE

Shewing Mean of Daily Rates of Sidereal Clock in each Month, obtained from 18 years observations.

MONTH.	Mean Rate.	Mean Pressure.	Mean Temperature.	Rate, + 0·0162 τ.
January	−2·4104	29·661	21·837	−2 0566
February	1·8020	·646	22·891	1·5212
March	1·7496	·614	28 380	1·2898
April	2·0637	·567	40 719	1·4041
May	2·8917	·576	52·581	2·0399
June	3·6429	·570	62·665	2·6277
July	3·9177	·579	68 677	2 8051
August	3 8571	·615	67·057	2·7708
September	3·6901	·671	59·547	2·7254
October	3·5706	·619	47 236	2·8054
November	3·3350	·635	34·840	2·7706
December	2·8320	·641	25 407	2·4204

The figures shew that the Clock is under compensated for temperature; but the larger portion of the variation in Rate, does not seem to be due to differences of temperature. If we take the residual temperature correction as ·0162 T, the rates for the months of July, Aug. Sept. Oct. and Nov., are brought into every close agreement, the losing rate then rapidly diminishes, and reaches its minimum in March, after which time it again rises, the rates as at temperature zero, with the correction ·0162 T, applied, are shown in column five of the Table.

The only way in which I can account for this, is by supposing that there must be a periodic shifting of the foundations of the Clock, which affects its rate. This supposition will perfectly account for the minimum occurring in March, when the amount of frost in the ground has reached its maximum. The rapidity with which the changes take place, varies a good deal from year to year, and at the beginning of December last, seems to have been unusually rapid. In obtaining the errors at various times, I have assumed, as being in close agreement with the observations, that the losing rate was diminishing at this time by ·07, of a second per day, independently of the Temperature residual of ·0162 T. The adopted errors of the Clock, when it showed 12 hours, on the different days, were accordingly, as follows:

Date.	Error.			Daily Rate.
	h.	m.	s.	s.
Nov. 28	5	16	50·88	3·28
" 29			54·16	3·20
" 30			57·36	3·15
Dec. 1			60·51	3·13
" 2			63·64	3·02
" 3			66·66	2·91
" 4			69·57	2·89
" 5			72·46	2·86
" 6			75·32	2·76
" 7			78·08	2·61
" 8			80·69	2·48

In taking the Transits for time, the collimation error was obtained by reflection from mercury, the level error was determined frequently, but I have been compelled to assume a uniform Azimuth error from the 29th of November to the 8th of December, as the weather was such that it was impossible to obtain satisfactory observations for determining the error of Azimuth between these dates, the agreement, however, between the errors obtained, from stars of different Declinations, was such, as showed, that any residual error was small as compared with the uncertainty of the Clock.

The following is an abstract of the observations for time .—

Date.	Star.		Corrected Clock. Time of Transit.			R. A.			Clock slow. Observed.			Calcd.	O-C.
			h.	m.	s.	h.	m.	s.	h.	m.	s.	s.	s.
Nov. 29	δ Draconis	Circle W.E.E.	13	55	34·63	19	12	29·11	5	16	54·48	54·42	0·06
	γ Aquilæ		14	23	46·82	19	40	41·38			54·56	54·48	0·08
	α "		14	28	9·61	19	45	4·04			54·43	54·49	−0·06
Dec. 2	Sun	Circle E.	11	22	40·61	16	39	47·28	5	17	6·67	6·58	0·09
" 3...........	α Ophiuchi		12	12	22·72	17	29	29·32			6·60	6·59	— ·09
" 4.................	γ_2 Ursae maj.	Circle E.	10	3	38·12	15	20	50·43			12·31	12·23	·08
	α Cor. Bor.		10	12	30·71	15	29	42·99			12·28	·24	·04
	α Serpentis		10	21	17·41	15	38	29·54			12·13	·26	— ·13
	η Draconis		11	5	9·40	16	22	21·78			12·38	·33	·05
" 6..	η Draconis	Circle E.	11	5	1·08	16	22	21·62			20·54	20·60	— ·06
" 7..	β "		12	10	25·05	17	27	45·35			20·30	·71	— ·41
	*γ "		12	36	31·13	17	43	51·48			20·35	·75	— ·40
	γ Cygni		15	0	40·87	20	18	1·27			20·40	21·00	— ·60
	α "		15	20	5·65	20	37	26·09			20·44	03	— ·59
	ν "	Circle W.	15	35	27·96	20	52	48·36			20·40	06	— ·6
	α Cephei		15	58	26·31	21	15	46·69			20·38	·10	— ·72
	β Aquarii		16	8	3·50	21	25	23·92			20·42	·12	— ·70
	*β Cephei		16	9	48·01	21	27	8·08			20·07	·12	−1·05
	ε Pegasi		16	21	5·94	21	38	26·46			20·52	·14	— ·62

* Three wires only.

The large discordance between the observed and calculated errors on the 7th, I ascribe to the rapid fall of temperature when the slit of the transit room was opened, the thin rod of the pendulum taking up the temperature of the air much faster than the large mass of mercury in the bob.

In the interchange of time, Chronometer, Russell & Son's No. 7,050 was employed, and the following errors were obtained by comparison, by the method of simultaneous beat between it and the Sidereal Clock :—

	h.	m.	s.		s.
Dec. 4th	4	1	13·25	Slow	26·39
5th	22	35	24·		26·99
5th	4	55	35·25		27·04
5th	20	30	25·		26·58
6th	4	50	45·		26·38
6th	10	8	45·5		26·24
7th	5	10	55·		26·27
7th	22	26	47·5		27·10
13th	21	47	24·		31·56
15th	1	5	47·		31·08

From these I have taken, as the errors at the times at which the interchange of time took place, the following:—

			s.
Dec. 5th	throughout	slow	27·04
6th	7 h.		26·32
	8		26·30
	9		26.27
	10		26·24

In signalling the time on the night of the 5th, the time signalled as an exact minute was the 33 seconds by the Chronometer, on the night of the 6th, the second signalled was the 34. The return signals from all stations, except Kingston, were made by hand either from Clock or Chronometer, and were estimated at Toronto, by ear. At Kingston the Toronto signals were taken down on a chronograph constructed by Prof. Dupuis, and the return signals were made by the Kingston clock, which was placed in circuit so as to beat every second except that at the exact minute.

The following shows the results of the comparison on the two nights:—

December 5th,—Toronto and Kingston.

Toronto sending.		Kingston sending.	
T. 11 16 33·00	K. 11 29 20·87	K. 11 46 0·	T. 11 33 12·30
27·04	43·25	43·27	27·04
11 17 0·04	11 28 37·62	11 45 16·73	33 39·34
	11 17 0·04	11 33 39·34	
	11 37·58	11 37·39	

December 6th,—Toronto and Kingston.

T. 9 28 34·00	K. 9 41 23·00	K. 9 57 0·00	T. 9 44 11·20
26·26	45·26	45·28	26·24
9 29 0·26	9 40 37·74	9 50 14·72	9 44 37·44
	9 29 0·26	9 44 37·44	
	11 37·48	11 37·28	

	m. s.		m. s.
Mean difference on 5th,	11 37·48	On 6th,	11 37·38

December 5th,—Toronto, Ottawa.

T. 10 4 23·00	O. 9 52 35·50	O. 9 58 12·09	T. 10 9 57·30
27·04	27 11·21	27 11·23	27·04
10 5 0·04	10 19 46·71	10 25 11·23	10 10 24·34
	10 5 0.04	10 10 24·34	
	14 46 67	14 46·89	

December 6th,—Toronto and Ottawa.

T.	9 29 4·00	O.	9 17 1·50	O.	9 40 30·00	T.	9 52 32·40
	26·26		27 16·27		27 16·31		26·24
	9 29 30·26		9 44 17 77		10 7 46·31		9 42 58·64
			9 29 30 26		9 52 58·64		
			14 47·51		14 47·67		

On the night of the 5th, the comparison with Cobourg gave, as the error of the Chronometer at Cobourg, on Toronto mean time fast, 2 m. 27· 3 s. at 14 hours; and on the night of the 6th, at 9 20 fast, 2 m. 29· 2 s.

The longitude of Toronto has usually been taken as 5 h. 17 m. 33·49 sec. W. This result was obtained by an interchange of time between Quebec and Toronto in January, 1857. Some recent interchanges of time have, however, led me to infer that it may be somewhat too small. Arrangements have now been made to connect Montreal Observatory with Cambridge, and an interchange will be made at the same time between Montreal and Toronto, the result of which I will furnish in a supplementary report.

At Ottawa, the chronometer which was employed was unfortunately subjected to a very great range of temperature. I have estimated as closely as I could, from Meteorological observations in Ottawa, the approximate temperature of the chronometer during various periods, from one set of observations taken there, to another, and the temperature when within the Hotel and Telegraph Office has been taken at 70° fahr., an estimate rather below than above the mark. The rate of the chronometer at different temperatures was taken from comparisons made in Toronto, one period extending from January 1st to February 11th, at a mean temperature of 29°.14, and a second period from February 12th to March 6th, at a mean temperature of 59°.35. The daily rate of this chronometer at temperature 29°.14 was found to be 7.892 sec. per day, and at temperature 59°.35—4.023 sec. Assuming the change of rate with temperature to be uniform and taking the error at 1 D. 7 H. 55 M. by chronometer as 26 m. 32.82 sec. I obtained the following tabular errors of the chronometer.

Date.			Error.	
D.	H.	M.	min.	sec.
1	7	55	26	32·82
3	9	49		53·38
5	8	30	27	11·92
5	19	30		13·14
5	20	30		·45
6	2	0		15·15
6	8	30		17·29
7	3	0		19·34
7	4	44		20·01

The error given by this table at 7 d. 4 h. 44 m. exceeded that obtained by observation by 1.28 secs. Dividing this change uniformly over the period from the first observation we should have errors and rates as follows:—

Date.			Mean Temp.	Hourly Rate.	Errors.	
D.	H.	M.				
1	7	55	18·56	·4029	26	32·82
3	9	49	16·33	·3881	26	52·92
5	8	30	70·00	·1017	28	11·04
5	19	30	32·00	·3045	27	12·16
5	20	30	33·00	·2991	26	12·46
6	2	00	29.00	.3205	27	14·11
6	8	30	70·00	·1017	27	16·19
7	3	0	18·00	·3792	27	18·09
7	4	44			27	18·73

This corrected table gives the error at 3 d. 9 h. 49 m. within 0·1 sec. of the observed error. In the above exchanges of time between Ottawa and Toronto, there is, however, a discrepancy between the mean of the results on the two nights of 0·81 sec. Assuming that the change was due to a uniform error in the assumed rate of chronometer 1752, we find for the errors on Toronto Mean time at the times of contact

1752, slow of T. M. T. at	2nd	contact	12	25·43
"	3rd	"	12	26·87
"	4th	"	12	26·95

In the exchange with Kingston taking the clock times as shown by the chronograph, and allowing, as in the case of Ottawa, for the difference between the errors at the time of exchange, we get as errors of the Kingston clock on Toronto Mean time, at the time of the several contacts, as follows:—

2nd Contact	12	21·58	Clock fast.
3rd "	12	22·03	"
4th "	12	22·08	"

The clock times of the contacts as measured from the Chronograph slips, with the corresponing Toronto mean times were as follows:—

	Clock.			T. M. T.		
	h.	*m.*	*s.*	*h.*	*m.*	*s.*
Ingress.						
Internal contact, second described phase	9	19	46·25	9	7	24·67
Egress.						
Internal contact, first " "	2	42	53·20	2	30	31·17
second " "	2	43	12·54	2	30	50·51
External contact	3	3	43·15	2	51	21·07

Cobourg had no transit instrument, and the time therefore depends entirely upon the exchange of signals by telegraph, interpolating we get for this error at the time contact was observed:—

Chronometer fast on Toronto mean time 2 min. 28·53 sec.

I append hereto the reports of the individual observers at the several stations where observations were obtained, except that from the station at Belleville, where, owing to atmospheric disturbance and other causes, the observation was not sufficiently accurate to be of value.

I have forwarded copies of this report to the Royal Society of Canada and to the Royal Astronomical Society of Great Britain. All of which is respectfully submitted.

CHARLES CARPMAEL,
Superintendent Meteorological Service of Canada.

TORONTO, 15th December, 1882.

Charles Carpmael, Esq., M.A., F.R.A.S., F.R.S.C.,
Superintendent of the Transit of Venus Observations
For the Government of Canada.

Sir,

I have the honor to report on the observations of the Transit of Venus taken at Ottawa, as follows:—

I was assisted in these observations by Mr. B. C. Webber, of the Meteorological Service, and the following instruments were used:—A four-inch Achromatic Telescope, alt-azimuth mounting, a Transit instrument by Messrs. Troughton and Simms, 2½ in. O.G., and Chronometer, Frodsham, 1752.

The temporary observatory was erected on Nepean Point, in Lat. 45° 26 N., and Long. 5 h. 2 m. 48 sec. W., approximate geographical positions.

On the evening of the 5th exchanged time with the Toronto Observatory, the weather being very cloudy and threatening to snow. The morning of the 6th broke with dense clouds at low elevation with no immediate prospect of breaking. Soon after 8 o'clock signs of clouds dispersing in S.E., 8.15 by chronometer, sun shone out brilliantly. Sighted on the sun, and focussed on sun spots at 8.24; rice grains on sun just discernible. Definition of telescope very fine. At first external contact atmosphere rather hazy. Time of first external contact 8 h. 34 m. 45 sec. by chronometer 1752, Frodsham. This time is not to be depended on, as my attention was called away just at moment of contact, and had to estimate, the notch being formed on the sun when I again put my eye to the telescope. I do not think it can be more than five or six seconds out at the most. At no time could I detect any portion of the planet that was off the sun. The portion on the sun was very black. Towards internal contact clouds began to pass over the sun, hiding it completely at times. Just before internal contact, caught a glimpse of the sun through a break in the clouds, which lasted long enough to catch the contact. No black drop observed. Bright cusps of sun met at 8 h. 54 m. 51 sec. The sun became obscured 8 h. 55 m. 08 sec., during which interval of 17 seconds the band of light between the limbs of Venus and the sun, broadened considerably. The time 8 h. 54 m. 51 sec. was last time of appearance of discontinuity in the illumination of apparent limb of sun. Sun re-appeared at 9 h. 11 m. with prospects of fine afternoon. For an hour, with the exception of the time occupied in the passage of a few fleecy clouds over the sun, the planet was observed. No markings of any kind could be distinguished on its surface, which appeared intensly black in comparison with the bright face of the sun. Clouds again gathered thickly and snow began to fall. Snow storm continued without intermission up till 2 h. 5 m., when clouds began to clear off in the south-west. At 2 h. 12 m. the sky was perfectly clear in south and west and the sun began to peep out, when Venus was observed approaching internal contact at egress, being then about half its own diameter from limb of sun. Mr. Webber commenced to count at 2 h. 16 m. At 2 h. 17 m. 19 sec. slight fading in light was observed near point of contact, which gradually increased until 2 h. 18 m., when contact was observed by first appearance of blackness like that of the planet, and the bright cusps began to recede. No black drop or distortion of the limb of Venus was observed, although the edge of the sun was boiling just a little. I used an illumination about midway between total darkness and brightness that the eye could just bear. When the planet was half way off the sun, I thought I could faintly discern the limb of the planet, but could not be sure of it. Between internal and external contacts nothing unusual was observed. At 2 h. 38 m. 12 sec. the dark body of the planet left the sun, although a faint shading of the limb of sun near point of contact till 2 h. 38 m. 31 sec. was observed, when nothing unusual in the illumination of limb of sun was observed after that time. For about an hour after external contact at egress the sun shone brilliantly, when clouds again arose and the sun was shrouded from sight for the rest of the day. I again exchanged time with the Toronto Observatory on the evening of the day of transit. A set of transits were taken at the observatory at Nepean Point on December 1st and 7th by Captain E. Deville, Chief Inspector of Surveys, and on the 3rd December by myself. These were the only time transits taken owing to unfavorable weather. The chronometer No. 1752 Frodsham was taken from the hotel to the Observatory on the 1st December, and left there till the evening of the 5th, when it was taken to the telegraph office to exchange time; it was afterwards taken to the hotel and put in the safe till morning of the 6th, when it was taken to the observatory and left there all day until evening, when it was again taken to the telegraph office, time compared, and then back to hotel safe; from there it was taken to the observatory on the evening of the 7th December, for timing transits. It was exposed to a good deal of variation in temperature, from 70° at the hotel on the 7th to 5° or 6° below zero, on Nepean Point Observatory; the temperature on the 6th was a little below the freezing point. Captain Deville compared my chronometer with Mr. Lindsay Russell's, who took the last two contacts at his own house. His chronometer was keeping sidereal time, and the following was the result of the comparison:

Dent .... 2071, = $20^{\text{h.}}$ $34^{\text{m.}}$ $40^{\text{secs.}}$
Frodsham ..... 1752, = $3^{\text{h.}}$ $01^{\text{m.}}$ $34{\cdot}5^{\text{secs.}}$

Dent .... 2071, = $20^{\text{h.}}$ $37^{\text{m.}}$ $45^{\text{secs.}}$
Frodsham ..... 1752, = $3^{\text{h.}}$ $04^{\text{m.}}$ $39^{\text{secs.}}$

TEMPERATURES AT OTTAWA DURING EARLY PART OF DECEMBER, 1882.

	6.59 A.	1 P.M.	9 P. M.	Mean.	Max.	Min.	
December 1st	28.3	31.5	19.2	26.33	31.8	18.1	The mean here is the actual mean of the three observations.
" 2nd	17.2	20.2	14.1	17.17	19.9	13.6	
" 3rd	9.0	10.6	4.2	7.93	13.9	4.1	
" 4th	− 4.9	8.1	14.1	5·77	14.1	− 5.8	
" 5th	30.3	35.2	30.1	31.87	36.2	13.9	
" 6th	31.3	34.2	22.2	29.23	......	21.5	
" 7th	29.9	22.5	5.1	19.17	29.6	4.8	
" 8th	− 2.9	5.1	0.1	0.77	6.9	− 2.9	

Your obedient servant,

(Signed), F. L. BLAKE, D. L. S.
COBOURG, January, 1883.

CHARLES CARPMAEL, Esq., M.A., F.R.A.S., F.R.S.C.,
Meteorological Observatory, Toronto.

SIR,

I have the honor to make the following report of the observations of the Transit of Venus which I, assisted by Drs. Haanel and Coleman, was enabled to make:—

The sky in the early part of the morning of December 6th, 1882, was clear enough to justify the most sanguine expectations of getting good observations of at least the first contacts, but a few minutes before 8 a.m. dense masses of clouds began to rise in the northwest, and by ten minutes past 8 the whole heavens with the exception of a small area in the northeast and east were covered, completely shutting out the sun from view. These clouds did not break away till long after external and internal contact at ingress were passed.

About 10.30 a.m. rifts in the clouds appeared and shortly before eleven a clear view of the planet on the sun's disc was obtained. The accompanying colored diagram No. 1, affords a very accurate idea of the appearance presented by the planet at that time and during the following two hours and three quarters. The disc of the planet especially towards its circumference presented a purplish hue while the centre had a faint light spot slightly tinged with a pale slaty green. Had photographic apparatus been furnished several impressions might have been taken very successfully from 11 a.m. till nearly 2 p.m.

Shortly before two the atmosphere which had been comparatively steady began to be disturbed and rapidly became worse while flying clouds now and again swept across the face of the sun. Before the time of internal contact at egress the boiling of the atmosphere was such as to render observations very unsatisfactory. The limbs of sun and planet appeared to spin. The limb of the sun at which contact was about to take place seemed to consist of filaments of light, each revolving swiftly in a small spiral.

Internal contact at egress appeared to take place at 2 h. 33 m. 27 sec. by the chronometer which was then 2 m. 29.5 secs. fast of the time at the Toronto observatory. Just at this critical time a cloud swept sun and planet out of sight, and when it had passed a small area of the planet's limb was decidedly beyond the suns limb, while a narrow beautifully distinct white line of light surrounded that portion of the planet's limb which was beyond the sun. The colored diagram No. 2 represents this line of light when about half the planet's disc had crossed the sun's limb and it faithfully represents the peculiar appearance presented by this line of light on the north western portion where it was decidedly broader than it was along the remaining arc. This peculiarity was noticed by each of the three observers without his attention being called to it by the others.

Very soon after the planet had passed the position figured in this diagram No. 2, clouds hid the sun from sight and prevented any observation being taken of the external contact at egress. The telescope used was a 4½ inch refractive equatorially mounted, and made by Smith, Beck & Beck, London, England. Power employed was about 150.

All of which is respectfully submitted.

Professor Bain further says in his letter, dated 25th January, 1883:—

I have the honor to acknowledge the receipt of your note of January 20th, in which you ask for a further description of phenomena seen at the instant of time at which I had marked down the words "ap. contact."

In the report already sent I refer to the atmospheric disturbance which grew worse and worse till all vision of sun and planet was lost under the flying clouds.

The ever narrowing bank of light over which the planet was slowly moving as it approached the sun's limb was heaving, boiling, and apparently spinning in manner described in previous report, other than this nothing peculiar was seen. No black drop presented itself, no distortion of the planet's limb, such as an elongation towards point of contact, nor till after part of the planet was beyond sun's disc did any arc of white light surround any part of the planets disc. The exact instant when that beautiful bright white arc of light first appeared, I know not, for just after what seemed to be contact a cloud came over, and when it was passed the arc of light was there. The cloud was on face of planet and sun fully five seconds.

It was impossible to take a point North and another South of the point at which contact was about to take place, and note when the illumination of the point of contact began to be distinctly less than that of the points chosen, for the sun's limb was not still enough to admit of any such thing. It appeared constantly to heave and surge.

With this exception the planet moved steadily towards contact, presenting no phenomena different from those observed at any earlier stage. The A B C D E were simply remarks made at the telescope while the observation was making; the exact words used, and the instant at which each phrase was spoken, being noted by the assistants. This plan was adopted, thinking that if any marked phenomenon presented itself near time of contact, before or after, the exact second of time when observed could thus be noted, but nothing in addition to the phenomena already described was seen.

In giving you the colors of the disc of planet, I described exactly as seen in our telescope; of course the purplish hue of the edge would at once inform you that our glasses are somewhat over corrected.

I forgot to mention that during the day the sun's surface was mottled, but presented no well-marked rice grains—no interlacing willow pattern.

I hope I have been able to make clear to you what was presented to our view on that day, from 11 a.m. until 2 h. 33 m, 38 sec. p.m.; that is, all phenomena that were seen, and the order in which and time at which they were seen.

Again, Professor Bain says, on February 21st, 1883, “In answer to your note 16th inst., I have the honor to reply that ‘ap contact’ means ‘approaching contact.’” Dr. Coleman put “ap” down in the hurry, but “approaching” was the word used.

Approximate position of observing station taken from United States Charts of Lake Ontario.

Latitude 43° 57 N.
Longitude 5 h. 12 m. 37·5 secs.

TIME NOTES. INTERNAL CONTACT AT EGRESS.

	h.	m.	sec.	
A	2	32	44	Atmosphere very unsteady.
B	“	33	5	Approaching contact.
C	“	“	27	Now.
D	“	“	33	Cloud.
E	“	“	38	Passed.
F				Illumination of Atmosphere of Venus. Violent boiling of Sun's surface, observations very unsatisfactory.

(Signed) A. R. BAIN.

REPORT OF THE OBSERVATIONS OF THE TRANSIT OF VENUS AT KINGSTON OBSERVATORY, CANADA, 6TH DECEMBER, 1882.

We had so far the advantage in preparing for the transit here that the longitude of the site of the former observatory building had been previously determined by every known method, continued for a number of years, as well as by telegraphic communication, to be 5h. 5m. 54.6 s. W., with a probable error of not more than two-tenths of a second.

Its latitude had been no less carefully ascertained by a series of observations near zenith stars,—particularly B. A. C. 4841, 5400, 6013, and 6731,—by transit with attached micrometer in the prime vertical, to be 44° 13′ 21″ 7 N.

The site of the new observatory building in which observations began to be taken last year is on higher ground, and a little further to the west, and the necessary triangulation being made the longitude and latitude of the equatorial pier from which the transit was viewed were found to be 5h. 5m. 56s. 4 W., and 44° 13′ 25″ 2 N. respectively.

The new Observatory is a neat frame building, containing, besides the apartment for the observers, the transit rooms and two rooms in the equatorial tower, and the arrangements for opening and closing the shutters, and revolving the dome, act perfectly both in winter and summer.

The instruments in the Observatory are the "Beaufoy transit," lent by the Royal Astronomical Society, and a small portable transit, by Simms, both in excellent order, in the tower; at the west end of the building is the Equatorial, by Alvan Clark. In the spare room below is preserved an interesting specimen of one of the best telescopes of the middle of last century, a reflecting Gregorian telescope constructed by Shortt in 1742, with 7-inch parabolic reflector, and the original stand for movements in altitude and azimuth.

This instrument was presented to the Observatory by Principal Leitch, of Queen's University. There are also mean time and sidereal clocks with excellent escapements, and compensation pendulums constructed by Professor Dupuis.

The instruments usually employed are the large Beaufoy transit and the Equatorial, and were those made use of in connection with the transit of Venus.

The Beaufoy transit has an object glass of three inches clear aperture and 50 inches focus. It is fitted with dew cap, with 5 vertical and 2 horizontal wires, and a striding level, the level has on it a new and accurate scale of divisions, each denoting one second of arc; the axis is supported on two pyramidal stone piers resting on a broad basis of the same material, which lies upon a solid mass of concrete extending deep into the ground.

The Equatorial has a 6¼-inch object glass of 8 feet focus, and at the end next the eye was fitted with a solar reflecting prism and neutral tint glass wedge; the eye piece employed in viewing the transit was a positive one, with a power of a hundred and twenty, which was found to give the sharpest and best defined vision of the limbs of the sun and planet.

Besides the clocks already referred to, two other time keepers were available, and the times of contact as given by these on the day of the transit were alone employed. The one was a half second M. T. chronometer, number 2382, by Parkinson and Frodsham, lent by the British Admiralty for the use of Canadian observers, and the other a very perfect M. T. clock in Prof. Dupuis' house, with compensation pendulum, and Denison's gravity escapement, and electrically connected both with a chronograph there and with the Observatory. Both the clock and chronograph are of Prof. Dupuis' construction, the rate of the clock is very steady, as the record below shows:—

CLOCK ERRORS.

	Seconds.
Dec. 3, 7 p.m.	38·49
" 5, 12 n.	43·29
" 6, 9 a.m.	44·11
" 6, 2 p.m.	44·56
" 6, 10 "	45·28
" 7, 7 "	47·19
" 8, 7 "	49·36

On the evening of the 5th December clock signals were received from Toronto as follows, and registered on the chronograph:—Toronto 17 m.; Kingston 29 m. 20·9 s.; clock error, + 43·29 s. And also on the evening of the 6th as under:—Toronto, 29 m.; Kingston, 41 m. 23 s.; clock error, + 45·28 s. On the evening of the 6th at 9 h. 28 m., 29 m., 30 m. and 31 m. Toronto M.T.

The corresponding times by Parkinson and Frodsham's chronometer at the Kingston Observatory were 9 h. 23 m. 14 s., 24 m. 14 s., 25 m. 14 s. and 26 m. 14 s., the chronometer being 16 m. 23·7 s. slow by Observatory time and having a daily losing rate of 3·77 s.

The difference between the mean times at Toronto and Kingston, therefore, from the result of these signal exchanges is 11 m. 37·7 s. Each second for four minutes of Kingston mean time was also on the evening of 6th signalled to Toronto.

Special observations were made for the determination of the rates of the chronometer and clock every time the weather permitted for upwards of two weeks before the day of the transit, and the evening of the 6th being very fine advantage was taken, soon after the transit was over, of observations of stars for ascertaining the Observatory time, and the rates with all possible precision, and of completing the examination for azimuth.

In the use of the transit for time the Equatorial thread intervals were ascertained by many observations of the principal circumpolar stars, and others to be:—

Seconds.
A. M. = 42·012
B. M. = 20·938
C. M. = 0·061
D. M. = 20·873
E. M. = 41·997

The error of pivots is + ·02 s.

The level constant on the day of transit was —·03 sec., and the collimation —·08 sec., the azimuth error in consequence of some settling of the piers which had been suspected since the last adjustment in azimuth, was + 1·09 sec. The collimation constant had been ascertained in the ordinary way by observations of the pole star with reversal, and that of azimuth by calculation from the observed times of passage of high and low stars.

The weather for a week before the transit had been very unfavorable, and we began to fear that our preparations would prove fruitless after all, but we were agreeably disappointed by the 6th of December being on the whole a fine day, particularly so in the afternoon. The early morning sky was overcast, as the time for the commencement of the transit approached, however, it became clearer, and Professor Dupuis and I repaired to our posts, while Mr. James M. Dupuis was at hand to render very useful assistance in various ways, as it might be necessary. One of the passing clouds which were beginning to disperse obscured the view of the first external contact, and the planet was in consequence not seen until it had partly entered on the sun's disc. This was at 8 h. 45 m. 5 sec. by chronometer, or 9 h. 0 m. 26·76 sec., Observatory mean time.

At 8 h. 53 m. by chronometer, or 9 h. 9 m. 21·8 sec. K.O.M.T.—a line of light appeared round the planet on the side away from the sun, and apparently brighter towards the southern limb of the planet.

The clouds had now passed away, and approach to the first internal contact was noted at 9 h. 1 m. 25 sec. by chronometer, and by chronograph connected with mean time clock.

The first internal contact itself, that is, when the limbs of the sun and planet appeared just to touch each other, took place as nearly as could be judged at 9 h.

1 m. 44 sec. by chronometer, or 9 h. 18 m. 5·81 sec. Observatory mean time. For a little while after, the limbs seemed slightly to separate, a dark shade occupied the narrow interval between them, extending a little way on each side of the former points of apparent contact. The time when this dark shade began to break away and disappear occurred at 9 h. 2 m. 40 sec. by chronometer, or 9 h. 19 m. 1.81 sec. Observatory mean time. This I regard as the true time of internal contact at ingress. There was still some remaining haziness in the atmosphere, but as the sky was bright and free from clouds at the time, both of these contacts were very distinctly seen. There was nothing of the so-called black drop, but only the dark shade already referred to.

Not long after the last contact at ingress, clouds began again to spread over the sky, and continued to do so until about noon, when they again gradually passed off, and from about 12 h. 30 m. p.m. to the end of the transit, as well as throughout the afternoon and evening the heavens were perfectly clear. The first internal contact at egress took place at 2 h. 25 m. 44.5 sec. by chronometer, or 2 h. 42 m. 7·15 sec. Observatory mean time. The dark haze seen at ingress in the morning began at this time to be again observed at egress, but the interval during which it continued, and discontinuity was noted, was much shorter than in the forenoon, the last internal contact at egress, that is, when the outlines of the limbs appeared exactly to touch, occurred at 2 h. 26 m. 4·5 sec. by chronometer, or 2 h. 42 m. 27·15 sec. by Observatory mean time. The former of these times I consider the true mean time of internal contact at egress. The last external contact took place at 2 h. 46 m. 35 sec. by chronometer, or Observatory mean time 3 h. 2 m. 57·71 sec.

(Signed) JAS. WILLIAMSON,
Director Kingston Observatory.

Kingston Observatory, 30th January, 1883.

McGill College Observatory,
Montreal, 20th December, 1882.

Charles Carpmael, Esq., M.A., F.R.A.S., F.R.S.C.,
Superintendent of the Transit of Venus Observations
For the Government of Canada.

Dear Sir,

I have the honor to make the following report on the Transit of Venus Expedition to Winnipeg, Manitoba.

I was assisted by Mr. H. V. Payne, Inspector for the Meteorological Office.

In accordance with your instructions I remained a day in Chicago in order to make arrangements for transmitting time signals between Winnipeg and Chicago. Colonel Cloury, Manager for the Western Union Telegraph Company kindly granted the free use of the Company's lines for this purpose, and Professor Hough, of the Dearborn Observatory, promised his co-operation.

We arrived in Winnipeg on Wednesday, November 22nd, and were received by His Lordship the Bishop of Rupert's Land, whose guests we were during our stay in Winnipeg, and to whose thoughtful assistance we owe much. The pier for the transit instrument had, under the direction of His Lordship, already been built and arrangements made for the erection of a shelter, which, with some additions, proved suitable for the purpose of our work.

The instruments placed under my care were a four-inch refracting, alt-azimuth telescope; a portable transit by Messrs. Troughton and Simms and two mean time chronometers—664 Tobias and 652 Murray. The telescope is in the possession of McGill College; it has a focal length of 62 inches, and was provided with a first surface reflecting prism, an Airy eye-piece of power 160, and a neutral tint wedge, the eye-piece and prism were made especially for this observation by Mr. Gundlach, of Rochester, N. Y., and the wedge is one purchased by you, being similar to those used in the British Observatories. The telescope has a slow motion worm gearing with handles for both altitudes and azimuth. The mounting is very steady. The tripod was unconnected with the floor of the shelter and rested directly on the ground. A rough adjustable seat was made at the station. The following will indicate the optical performance of the telescope :

1. The disc of a bright star out of focus is round, but has a somewhat jaggy edge. There is the usual change of colors as the eye-piece is pulled out, namely,—from greenish to a green centre bordered by purple, and beyond focus a purple centre bordered by green changing as it is pulled still further out to a uniformly light purple disc.

2. On a night of not very good definition and full moonlight σ Cassiopeæ was easily seen double.

3. The rice-grains on the sun on the day of the transit were just visible with the thin edge of the wedge.

The transit instrument belongs to the Observatory, Quebec. It has a clear aperture of 1¾ inches. It was mounted on a brick pier, two feet by two feet, capped with stone and built from a depth of six feet below the surface of the ground.

The chronometer 664 is the property of the McGill College Observatory; it was repaired and cleaned by the Messrs. Bond, of Boston, for use on this expedition. The chronometer 652 is the property of the British Admiralty, being loaned for the purposes of the transit of Venus Observations in Canada.

The instrument shelter was ten feet by fourteen, and was divided into two compartments. The roof was flat and sloped towards the south; it was made in part; moveable in the telescope room, giving an uninterrupted view of the sun during the time of the transit.

The transit room was provided with the usual opening. A photograph of the station is presented herewith.

On unpacking the transit instrument, the striding level was found to have been broken. Two levels were at once forwarded to me from Montreal, one of which reached me unbroken. Previous to its arrival I was fortunate enough to meet Mr. Drummond, D.L.S., in Winnipeg, and to obtain from him a small striding level made by Messrs. Troughton & Simms. This level on being attached to the broken one by wooden clamps served to determine the inclination of the axis within small range. The value of one division of this bubble was found to be three and nine-tenths seconds of arc (3.9″). Owing to the shortness of the bubble the transit had to be levelled at the beginning of each evening's work. The value of one division (one-sixteenth of an inch) of the Montreal bubble was (2.4″) two and four-tenth seconds of arc.

On the 27th November the transit instrument was roughly got into position, and on this and the following night a number of star transits for wire intervals were obtained. These with the resulting equatorial intervals are given in a table attached hereto. While the number of stars observed is much too few to obtain permanent intervals from, I consider the intervals obtained to be sufficiently near the truth for the purpose in view.

The first observations for time were made on November 29th, the Drummond level being used. The errors of the chronometers for this and subsequent determinations are given in a table appended hereto. Cloudy weather prevented further observations until December 4th, when time was carefully determined. Tables are given herewith showing details of time determinations on December 4th, 6th and 7th. On December 6th a solar in addition to siderial observations was obtained.

Through the courtesy of the Great North Western Telegraph Company and Mr. McDougall, Manager of the Winnipeg office, the line from Winnipeg to Selkirk was cut and passed through our observing station. This gave connection with the Dearborn Observatory at Chicago through relays at Chicago and St. Paul's.

TIME SIGNALS FOR LONGITUDE.

The signals received were those of the clock at the Dearborn Observatory. This clock closes the circuit at intervals of two seconds up to the 52nd second for each minute, except before every 5th minute when the last contact is made at the 40th second.

December 4th, p.m., signals were received during 12 minutes:—

7h. 22m. 18·35sec. on chronometer, 652 = 8h. 0m. 00sec. on Dearborn clock.
21·3 chronometer fast 00
7h. 21m. 57·05sec. meantime at Winnipeg = 8h. 0m. 00sec. Chicago M.T.
Observed difference in time 0h. 38m. 02.95sec.

December 5th, p.m., signals were received during 3 minutes:—

7h· 32m. 17·7sec. on chronometer 652 = 8h. 10m. 0·0sec. on Dearborn clock.
20·1 chronometer fast 0·1 clock fast.
7h. 31m. 57·6 sec. Winnipeg mean time = 8h. 9m. 59·9 Chicago M.T.
Observed difference in time 8h. 38m. 02·3sec.

Mean of differences on December 4th and 5th	0h. 38m. 02·62sec.
Allowance for armature and current time	0·12
Reduced difference in time	0h. 38m. 02·74sec.
Longitude of Dearborn Observatory	5h. 50m. 26·78sec.
" Winnipeg station	6h. 28m. 29·52sec.

Time signals were also received and sent on the night of December 8th, but as no time observation was made subsequent to the 7th, and the rate of the standard chronometer was not very well determined, I do not consider that a reliable difference of time can be obtained from the exchange. This was the only night on which my signals were received at the Dearborn Observatory. My signals were sent by hand and received on a chronograph. The difference of time thus recorded as given to me by Professor Hough is precisely the same—to a tenth of a second—as the difference observed by me. These times should differ by twice the armature and current time. The error is no doubt almost entirely due to my imperfect sending, which besides being by hand was not otherwise under favorable circumstances. The signals received could be compared with the chronometer to the nearest tenth of a second with ease. On account of these circumstances, I have thought that greater accuracy could be obtained by making the difference of longitude depend on differences obtained in one direction only; adding an armature and current time as above.

As will be observed on reference to the table giving chronometer errors, a time determination was made on December 4th; this was immediately after the exchange of time signals. On December 5th, there was no observation but time was well determined on the 6th.

It might be proper to give greater weight to the difference in longitude obtained on the night of the 4th. But this refinement seems, under the circumstances, to be useless. No attempt was made to determine a personal equation between Professor Hough and myself.

The great difficulty experienced in the running of chronometers, referred to elsewhere, made it quite impossible to obtain a very accurate determination of longitude. I consider the above result to be within one second of the truth.

It may be proper to add that the longitude of the station as taken from the map of the Government Lands Survey is 6 h. 28 m. 29·0 sec.

Advantage was taken of every clear day to practice with the telescope, making record of times as if the transit of Venus were actually taking place.

The method of recording times, which was adopted, was as follows:—Mr. Payne called out the seconds from 0 to 60 and made a record of each minute as it passed. When I called "now" he wrote the corresponding second—to the nearest half second—in a column opposite to the minute previously recorded. Having made this entry he continued counting until another signal was given. After the second signal time was recorded, Mr. Payne wrote from my dictation what was supposed to have been observed.

This method was strictly adhered to during the actual observation, and a short statement of what was observed was written immediately after each contact.

On the morning of December 6th, the sun was obscured by cloud and snowdrift until after 9 o'clock. When the sun had risen above the cloud and snowbanks it remained visible until it had again sunk behind them in the afternoon. The temperature during the time of the observation of contact was 18° below zero, Faht., and the velocity of the wind was 24 miles per hour.

On reaching the station shortly before 11 a.m., and directing the telescope on the sun it was found to shake so violently as to make it impossible to keep the sun in view. We immediately set to work to screen the telescope from the wind. After moving it back so that it stood entirely within the shelter, we covered the roof opening with the exception of a hole about one foot square, through which the sun could be seen for some time before and after contact at egress. The telescope was then found to be perfectly steady. All arrangements were completed and the telescope directed on the sun at shortly before 1 o'clock, from which time until after the third contact Venus was kept in the field of the telescope, principally by Mr. Payne, as I wished to rest my eyes as much as possible before making the observation.

OBSERVATIONS OF 3RD AND 4TH CONTACTS.

Time record from Murray chronometer No. 652. At shortly after 1 h. 19 m. Mr. Payne began counting seconds. The following is an exact copy of the records:—

	h.	m.	s.	
Internal Contact at Egress.	1	20		
		21	55	*Light about to be broken.
		22	11	*Blackness all the way across a second or two before this.
		24		
External Contact at Egress.	1	40		
		41		
		42	13	*Last appearance of gap, approximate.
		43		

Rice-grains just visible at third contact, illumination poor. Extreme thin end of wedge used giving too dark a field, but sun very much too bright to be observed without the wedge. This applies more particularly to the fourth contact. At times near the third contact the illumination was nearly as bright as I desired, but considering the observation as a whole the field was too dark. I should say that the time of actual internal contact—the first appearance of any well marked and persistent discontinuity in the illumination of the sun near the point of contact—was considerably nearer the first time, 1 h. 21 m. 55 sec. uncorrected, than the last, 1h. 22 m. 11 sec. The time I would wish to be taken as the moment of contact as above defined is 1h. 22 m. on chronometer, which was at the time of the observation 60·6 sec. fast, making the actual local time of contact 1h. 20m. 59·4 sec.

At 1 h. 42 m. 13·0 sec. equal 1 h. 41 m. 12·4 sec., local time, there was the slightest possible appearance of a gap in the limb of the sun. Just then the illumination became very bad, and my eye being rather tired, I lost sight of the point of contact.

I have preferred to give my notes as made during the progress of the observations and immediately after them, rather than what might perhaps better express my meaning, written at this time.

I desire, however, to make the following additions to these notes: Definition was fairly good, there being little or no boiling on the limb of the sun. My remarks as to illumination were written immediately after the fourth contact, and were made with the then condition of the atmosphere on my mind, and were undoubtedly intended to refer to that time only. These remarks are, however, correctly qualified in what follows them. The important point is that at third contact the seeing was sufficiently good to leave no doubt whatever as to what I saw. There was no black drop but merely a haze or smoky darkness which gradually increased to complete blackness. There was no haze at 1 h. 21 m. 55 sec., chronometer time, but it was the last instant at which I could definitely say there was no appearance of a haze. I waited rather too long before giving the second signal at 1 h. 22 m. 11 sec., chronometer time, and for this reason made the note attached thereto.

The time I have indicated as what I would desire to be taken as the time of third contact must be very near the truth.

I stopped observing at 1 h. 24m., and did not recommence until 1 h. 39 m.

The word approximate following the remark opposite to 1 h. 42 m. 13 sec. does not express what was intended. At that time the gap was seen, but it was not seen afterwards. Had I continued to see it I do not think that any appearance of "gap" would have been visible for more than five seconds after the recorded time. I am able to judge of this somewhat closely from my model practice.

The minutes entered in the record preceding and following times of contact are the minutes during which counting was continued. After both internal and external contacts I verified Mr. Payne's counting by looking at the chronometer and his record while he still continued to count seconds.

I am your obedient servant,

(Signed), C. H. McLEOD.

COMPARISONS OF ERRORS OF CHRONOMETERS.

MURRAY 652, and TOBIAS 664, at WINNIPEG.

(Bishop's Court, St. John's College.)

Day. 1882.	Hour.	664		Errors. + fast; − slow.		Remarks.
		Fast of 652.	Slow of 652.	664	652	
Nov. 22	8 p.m.		38.5			
" 23	"		35.8			
" 24	"		33.3			Up to 8 p.m. on the 27th both chronometers were in a room, mean temperature about 65° with a range of perhaps 20°.
" 25	"		31.3			
" 26	"		29.3			
" 27	"		26.9			664 in transit house on 27th from 8 to 10 p.m.
" 28	"		21.4			664 in transit house on 28th from 8 to 12 p.m.
" "	12 m.		22.4			
" 29	9 a.m.		22.4			
" "	8 p.m.		22.0			664 in transit house; temp. 11°.
" "	12 m.		18.3	+6.1	+24.4	Errors from observation.
" 30	9 a.m.		17.8		+24.1	Error from rate.
" "	10 p.m.		16.3			
Dec. 1	9 a.m.		15.8		+23.5	" " "
" "	5 p.m.		15.3			664 in transit house (from 5 to 7 p.m., temp. −5°.
" "	7 "		17.2 (?)			17·2 probably a mistake for 7·2.
" "	8 "		7.5			664 in transit house at temp. −2°.
" "	10 "		4.0			
" 2	9 a.m.		3.3		+22.9	Error from rate.
" "	11.30 "		3.2			Owing to unsteady running of 664 on exposure, it was decided to use it hereafter as the standard, and 652 for transit work.
" "	2 p.m.		3.0			
" "	8 "		2.3			
" 3	9 a.m.		1.2	+21.1	+22.3	Errors from rate.
" "	9 p.m.		0.7			
" 4	8 a.m.	0.5		+22.2	+21.7	
" "	6.30 p.m.	1.1				652 exposed during transit work to temp. 0°.
" "	11 p.m.	1.5		+22.6	+21.3	Errors from observation.
" 5	9 a.m.	1.9				
" "	10 "	2.2				652 in transit house, temp. 8° below zero.
" "	1 p.m.	2.3				
" "	6 "	2.6		+22.7	+20.1	652 in transit house, temp. 11° below zero.
" "	11 "		42.8			Jump forward occurred after receiving Chicago time, probably in carrying chronometer home.
" 6	7 a.m.		41.8			652 at observing station; temp. 11° below zero.
" "	9 "		42.2			

COMPARISON AND ERROR OF CHRONOMETERS.

MURRAY 652 AND TOBIAS 664, AT WINNIPEG (ST. JOHN'S COLLEGE).

Day.	Hour.	664		Errors + fast; − slow.		REMARKS.
		Fast of 652	Slow of 652	664	652	
Dec. 6	11 a.m.		41.8			652 taken to observing station, temp. 18° below zero.
"	Noon				+60.7	Solar observation.
"	2.45 p.m.		37.8		+60.5	From comparison with standard.
"	4 15 p.m.		37.4	+22.7	+60.1	652 transit work; temp. 25° below zero.
"	8.45 p.m.		37.5			Errors from siderial observations.

After 10 p.m. December 1st, 664 remained in the room first-mentioned (the dining room at Bishop's Court, St. John's College).

The change in going of chronometers on exposure to severe cold, as observed here, is not governed by any rule. The observing station was situated at a considerable distance (10 minutes walk) from Bishop's Court.

TIME OBSERVATIONS.

The following tables give details of time observations made on December 4th, 6th and 7th. I regret that the results are so discordant, but with the very erratic going of chronometers, against which I had to contend, it was simply impossible to do nice work.

The chronometer used for observing was 652. It was selected at the Toronto Observatory from a number of chronometers as the one which had the steadiest rate. The stars observed are from the American Ephemeris.

TRANSIT OBSERVATIONS.

Latitude 49° 55′ N., Longitude 6 h. 28 m. 29.5 sec. West.

Date. 1882.	Star.	Declination.	Culmination.	No. of Wires.	Observed Mean time of Transit by Chro. 652.	Mean time of Stars. Passage.	Observed Chronometer Error.	Instrum. Errors corrected for				Remarks.
								Level.		Azimuth.		
Dec. 4.	η Ursæ Maj.	N. 49° 54′	L	5	8, 47, 49.64	8, 47, 36.53	+ sec. 13.11	+ sec. 13.06				The inclination of axis was observed as follows:— 8 p.m. = W. +0.16 sec; 10.15 p.m. = W. + 0.62 sec.; 10.45 p.m. = W. + 0.62 sec. The correction for inequality of pivots is included in the above level errors:— It is W. + ·16 sec. for lamp east.
	α Draco	N. 64° 56′	L	5	9, 06, 00.64	9, 05, 49.70	10.94	10.67				
	4 Draco.	N. 78° 15′	L	2	7, 11, 41.60	7, 11, 36.90	4.70	4.22				
	β Arietis	N. 20° 14′	U	5	8, 53, 11.68	8, 52, 53.63	18.05	18.33		21.09	Lamp East.	
	η Piscium	N. 14° 45′	"	5	8, 30, 17.22	8, 29, 59.95	17.27	17.45		20.57		
	o Piscium	N. 8° 34′	"	5	8, 44, 14.74	8, 43, 57.21	17.53	17.73		21.19		
	θ′ Ceti	8° 47′	"	5	8, 23, 14.98	8, 22, 57.95	17.03	17.14		21.61		
								Mean	-	21.11		
	β Ur Min.	N. 74° 38′	L	4	9, 55, 35.10	9, 55, 28.88	6.22	5 07				
	5 Ur Min.	N. 76° 13′	L	8	9, 32, 20 64	9, 32, 16.04	4.60	3.45			Lamp West.	
	α Persei	N. 49° 27′	U	3	10, 20, 47.80	10, 20, 28.30	19.50	20.50		20.6		
	α Ceti	N. 3° 38′	"	3	10, 00, 59 46	10, 00, 41.70	17.76	18.16		21.9		
	γ Ceti	N. 2° 44′	"	5	9, 42, 07.53	9, 41, 49.20	18.33	18.70		22.4		
								Mean	-	21.63		
	δ Persei	N. 47° 25′	"	3	10, 39, 21.46	10, 39, 02.65	18.81	20.3		20.6	Lamp East.	
	η Tauri	N. 23° 24′	"	5	10, 45, 14.38	10, 44, 56.80	17.58	18.5		21.0		
							2nd Set. Mean		-	20.8		

Mean Chro. error, lamp east is + 21.11
" " " west is + 21.63
Chro. 652, fast + 21.37

COMBINATIONS FOR AZIMUTH.

Lamp East.		Lamp West.	
η Ursæ Majoris and β Arietis	= 5.27.	β Ursæ Minoris and γ Ceti	= 5.75.
α Draconis and η Piscium	= 4.4.	5 Ursæ Minoris and α Ceti	= 5.5.
α Draconis and o Piscium	= 4.74.	Mean	= 5.62.
4 Draconis and θ′ Ceti	= 4.31.		
Mean	= 4.63.		

Mean of Lamp W. and Lamp E. = + 5.15.

Time Determinations from Transit Observations

at Winnipeg; Latitude 49° 55′ N.; Longitude 6h. 28m. 29.5 sec. W.

Date.	Star.	Declination.	Culmination.	No. of Wires observed.	Mean time of Stars. Passage.	Observed Time of Transit on Chro. No. 652.	Observed Chronometer Error.	Corrected for error of Level.	Chromr. Rate.	Azimuth. (2.2 sec.)		Remarks.
Dec. 6.,	λ Draconis...	N. 69° 59′	L	5	6, 20, 38.57	6, 21, 35.72	+ sec. 57.15	56.64				
1882...	θ Draco (H)..	N. 76° 19′	L	2	5, 22, 30.25	5, 23, 23.50	53.25	52.85		(2.2 sec.)		Inclination of axis observed as follows: 5h. 20m. = W + ·16 sec.; 6h. ·35 min. = W + 40.
	G.R. 4,163	N. 78° 46′	U	4	6, 46, 21.04	6, 47, 23.90	62.86	64.18				
	o Cephei.....	N. 67° 29′	"	4	6, 11, 05.92	6, 12, 08.50	62.58	63.33				
	ι Cephei	N. 65° 35′	"	5	5, 42, 51.30	5, 43, 53.64	62.34	62.87				Going of Chro. probably not very steady, although its total change during exposure, from standard Chro. was only 1·10 of a second.
	α Andromedæ	N. 28° 27′	"	5	6, 59, 28.46	7, 00, 28.46	60.00	60.40		61.32	Lamp East.	
	Markab......	N. 14° 35′	"	4	5, 56, 13.79	5, 57, 13.20	59.41	59.62		60.94		
	ω Piscium...	N. 6° 18′	"	4	6, 50, 27.39	6, 51, 26.80	59.41	59.70		61.24		
	ι Piscium ...	N. 5° 0′	"	5	6, 31, 03.18	6, 32, 03.08	59.90	60.17		61.78		
	Fomalhaut ..	S. 30° 15′	"	5	5, 48, 29.70	5, 49, 28.08	58.38	58.48		60.74		
								Mean	-	61.2		Note—Position of instrument in azimuth was chang'd on 5th at about 7 p.m.
	4 Draco (H)..	N. 78° 16′	L	3	7, 03, 45.33	7, 04, 47.05	61.72	61.72		(zero.)		
	32$_2$ Camelop (H)	N. 84° 02′	"	4	7, 45, 06.34	7, 46, 06.74	60.40	59.90			Lamp West.	
	α Cassiopeæ.	N. 55° 54′	U	5	7, 30, 56.23	7, 31, 54.54	58.31	58.07				
	β Andromedæ	N. 35° 0′	"	5	8, 00, 09.56	8, 01, 08.06	58.50	58.73		58.73		Inclination of axis observed as follows: 7h. ·15m. = W − ·15 sec.; 8h. ·15 m. = W + ·15 sec. No deviation in azimuth here.
	ε Piscium...	N. 7° 15′	"	3	7, 53, 51.39	7, 54, 50.17	58.78	58.90		58.90		
	β Ceti........	S. 18° 38′	"	4	7, 34, 44.97	7, 35, 44.34	59.37	59.37		59.37		
								Mean	-	59.00	Lamp East.	
	γ Piscium ...	N. 14° 45′	U	3	8, 22, 08.10	8, 23, 06.86	58.76	59.02				
	θ′ Ceti........	S. 8° 47′	"	3	8, 15, 06.12	8, 16, 04.97	58.85	59.02				Instrument probably disturbed on reversal.
					Error of Chro. = $\frac{61.20 + 59.00}{2}$ =					60·1		

In first set on combining for azimuth as follows:—
ι Cephei and Fomalhaut = 2.5; *o* Cephei and *ι* Piscium = 2 1; Groombridge 4163 and ω Piscium = 2.1; 9 Draconis and Markab = 2.4; α Draconis α Andromeda = 1.8.

$$\frac{2.5 + 2.1 + 2.1 + 2.4 + 1.8}{5} = 2.2$$

The mean azimuthal deviation to be obtained from the 2nd set is about "Nil."

The collimation error obtained by reversal on two stars (on the 4th) was only + .05 sec. The 3rd set of observations being compared with the second (above) shows this correction to be still very small.

Time Determination from Transit Observations at Winnipeg.

Latitude 49° 58′ N.; Longitude 6 h. 28 m. 29.5 sec. W.

Date. 1882.	Star.	Declination.	Culmination.	No. of Wires observed.	Mean time of Stars. Passage.	Observed Time of Transit. Chro. 652.	Observed Chronometer error.	Chronom. error corrected for error of				Remarks.
								Level.	Chronr. rate.	Azimuth.		
							+sec.					
Dec. 7.	β Ursæ Min..	N. 74° 38′	L	5	9, 43, 41.26	9, 44, 39.20	57.94	55.00	55.80		Lamp East.	Inclination of axis observed as follows:— h.m. 9 40 = W 1.50 sec. 10 45 = W +0.56 Chro. rate as deduced from comparison before and after exposure — 0.4 sec. per hour. Reduced to 9pm beginning of exposure.
	48 Cephei (H)	N. 77° 18′	U	3	9, 58, 19.74	9, 59, 13.47	53.73	58.53	58.93			
	δ Persei......	N. 47° 25′	"	5	10, 27, 14.91	10, 28, 10.40	55.59	56.74	57.34			
	ζ Persei......	N. 31° 32′	"	5	10, 39, 23.17	10, 40, 19.06	55.89	56.55	57.22	57.22		
	ζ Arietis.....	N. 20° 37′	"	3	10, 00, 53.06	10, 01, 49.27	56.21	57.31	57.71	57.71		
	α Ceti.........	N. 3° 37′	"	5	9, 48, 53.97	9, 49, 50.16	53.19	57.15	57.48	57.48		
	ε Eridani....	S. 9° 51′	"	5	10, 20, 04.12	10, 21, 00.74	56.62	57.08	57.60	57.60		
								Mean	-	57.50		
	ε Ursæ Min..	N. 82° 14′	L	5	11, 50, 10.40	11, 51, 14.40	64.00	61.25	62.40		Lamp West.	Inclination of axis observed as follows:— h.m. 11 15 = W+0.16sec 12 15 = W+0.88. There is no appreciable azimuth deviation in either position.
	α Camelop...	N. 66° 08′	U	2	11, 34, 55.07	11, 35, 49.74	54.67	55.47	56.30			
	α Aurigæ.....	N. 45° 52′	"	4	12, 00, 26.47	12, 01, 22.16	55.69	56.67	57.87			
	ι Aurigæ.....	N. 32° 50′	"	5	11, 41, 48.77	11, 42, 44.48	55.71	56.20	57.28	57.28		
	β Tauri......	N. 28° 30′	"	4	12, 11, 15.06	12. 12, 10.62	55.56	56.44	57.68	57.68		
	ε Tauri.......	N. 18° 55′	"	5	11, 14, 17.59	11, 15, 13.46	55.87	55.92	56.82	56.82		
								Mean	-	57.26		
						At 9 p.m. Error of Chro.				57.38		

SOLAR TRANSIT, 6TH DECEMBER, 1882.

Declination.	Observed Time. Passage. 1st Limb.	Observed Time. Passage. 2nd Limb.	Chronometer reading for Transit of Sun's centre.	Mean time of Sun's passage.	Observed Chronom. error.	Chronometer error corrected for azimuth + 2.2 secs.
S. 22° 34′	11, 51, 09.98	11, 53, 31.06	11. 52, 20.52	11, [illegible]	58.49	60.75

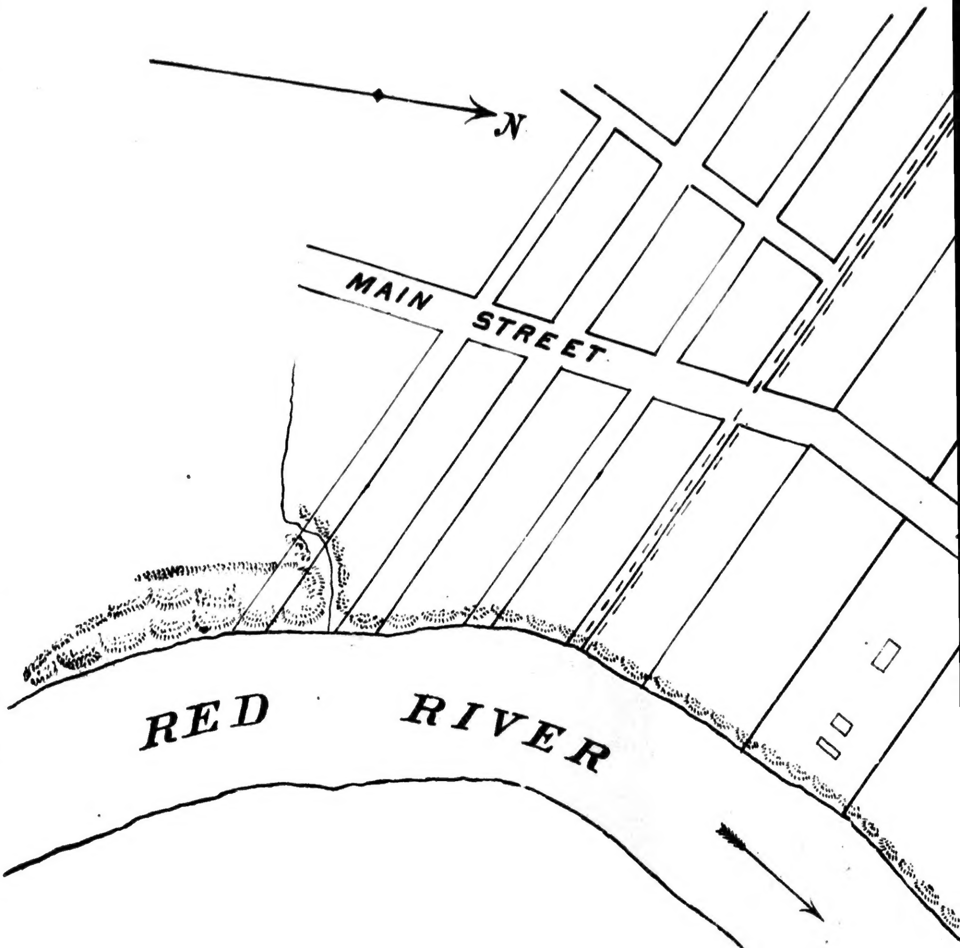
The azimuthal deviation used to reduce solar observation is that obtained from observations on the night of the 6th before reversal. As the collimation error is very small and the level correction (error was not observed through inadvertence, but the temperature of the air being nearly the same as at 5 p.m., when W. was — ·16, it could not be great) in this position necessarily small, this result does not appear to be more than a small fraction of a second in error.

Determination of Equatorial Intervals of Wires in Transit Instrument.

TROUGHTON AND SIMMS, MAKERS,

Focal Length, 24 inches. Clear Aperture, one and three-quarter inches.

DATE, 1882.	STAR.	Observed Intervals.					Equatorial Intervals.					
		1	2	3	4	5	1	2	3	4	5	
		+	+		−	−	+	+		−	−	
Nov. 27th.	38 Cassiopeae....	86.26	43.56	+.06	42.4	87.44	29.99	15.14	+.02	14.75	30.22	
" "	ι Cassiopeae.....	76.70	38.70	−.30	37.80	77.30	30.12	15.20	−.11	14.84	30.35	
" "	50 Cassiopeae....	96.74	48.74	−.06	47.86	97.56	30.13	15.18	−.02	14.90	30.38	Lamp East or Clamp West.
" 28th.	α Cygni..........	42.28	21.48	—	21.22	43.02	29.97	15.22	—	15.04	30.49	
" "	α Cephei.........	64.36	32.56	−.34	31.94	64.64	30.11	15.23	−.16	14.95	30.25	
" "	α Ursæ Majoris..	64.86	32.86	−.14	32.14	65.44	30.07	15.23	−.06	14.90	30.34	
" "	θ Bootis.........	48.90	24.90	+.20	24.40	49.60	29.84	15.19	+.12	14.89	30.26	
" 29th.	β Ursae Min.....	113.70	57.70	−.06	56.00	114.10	30.13	15.29	−.02	14.84	30.33	
" "	δ Persei..........	44·24	22.74	+.04	22.26	44.76	29.94	15.39	+.02	15.06	30.28	
" "	5 Ursae Min.....	126.30	64.10	+·40	62.90	127.90	30.09	15.27	+.09	14.99	30.47	
" "	ζ Ursae Min.....	146.70	74.20	+.70	72.80	148.80	30.13	15.24	+.14	14.95	30.56	
							30.048	15.234	+.002	14.918	30.358	Means.



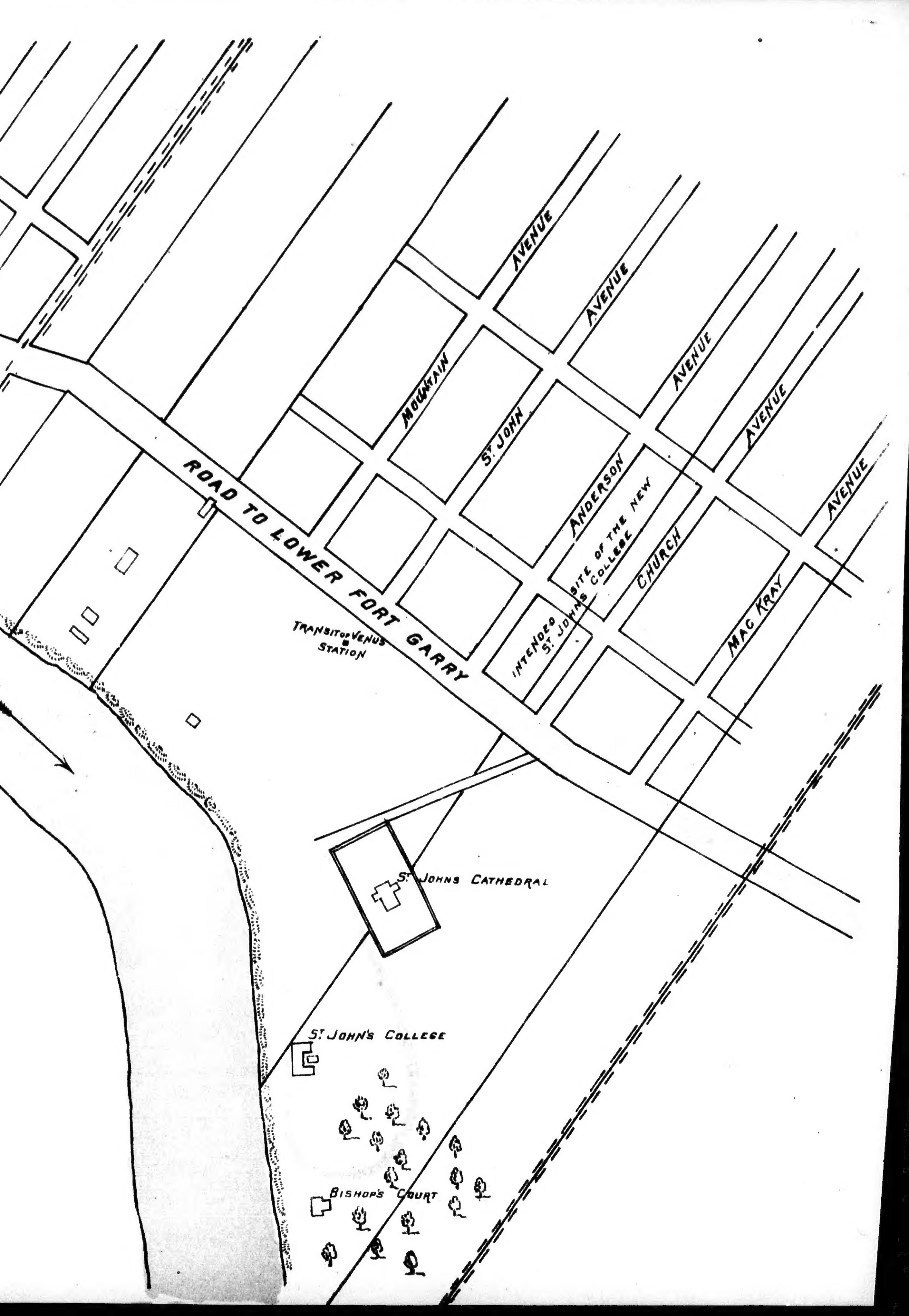
# PLAN

SHEWING POSITION OF TRANSIT OF VENUS STATION
AT
WINNIPEG MAN.

6TH DECEMBER 1882

Scale 6 Chains (396 FT)
equal to one inch

UNCOLOURED STREETS ARE NOT YET BUILT UPON.-


MOUNTAIN AVENUE
ST. JOHN AVENUE
ANDERSON AVENUE
CHURCH AVENUE
MAC KRAY AVENUE
AVENUE
ROAD TO LOWER FORT GARRY
TRANSIT OF VENUS STATION
INTENDED SITE OF THE NEW ST. JOHNS COLLEGE
ST. JOHNS CATHEDRAL
ST. JOHN'S COLLEGE
BISHOP'S COURT